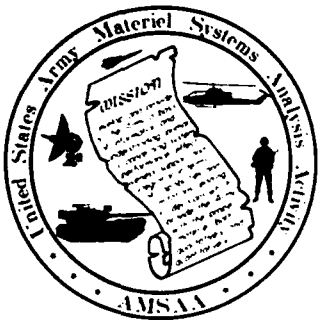

ARMY MATERIEL SYSTEMS ANALYSIS ACTIVITY

TEST DESIGN PLAN (TDP) FOR THE PRODUCTION QUALIFICATION TESTING (PQT) OF THE 81MM M984/M983 HIGH EXPLOSIVE (HE) CARTRIDGES

OCTOBER 1992

U S ARMY MATERIEL SYSTEMS ANALYSIS ACTIVITY
ABERDEEN PROVING GROUND, MARYLAND 21005

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PRODUCTION QUALIFICATION TESTING (PQT)

OF THE

81MM M984/M983 HIGH EXPLOSIVE (HE) CARTRIDGES

GREGORY E. WOOD

OCTOBER 1992

U.S. ARMY MATERIEL SYSTEMS ANALYSIS ACTIVITY
ABERDEEN PROVING GROUND, MD 21005-5071

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Test Design Plan (TDP) for the Production Qualification Testing (PQT) of the M984/M983 High Explosive (HE) Cartridges

1. INTRODUCTION

1.1 Purpose.

The purpose of this TDP is to indicate the recommended testing required to support an evaluation of the initial production M984 and M983 Cartridges. This TDP discusses the following: sample sizes, extent and severity of test, environmental conditions, order of testing, required data, accuracy of measurement, and confidence levels.

1.2 Objective.

The objective of this TDP is to assure that adequate data will be obtained, at a minimum cost and effort, to enable the evaluation of those issues that are amenable to the testing and are critical to the decision process. Consideration was given to the previous testing of these cartridges and the 81mm, M879 Full Range Practice Cartridge so that redundant testing is avoided.

1.3 Description of Cartridges.

The M984/M983 HE Cartridges are a US design improvement to the United Kingdom (UK) produced M821/M889 HE Cartridges. The new design is intended to reduce production and facilitization costs while maintaining the performance, reliability, safety and human factors characteristics of the UK produced cartridges. The US design changes include a high fragmentation steel body instead of a cast iron body and also include Composition B rather than TNT as the HE filler. The new design utilizes the M24 fin assembly, the M299 ignition cartridge, and the M220 propellant charge assembly that are used on the 81mm M879 Full Range Practice Cartridge. The only difference between the M984 and the M983 are the fuzes. The M984 is assembled with the M734 Multioption Fuze (MOF) which is currently used on the 81mm M821 and 60mm M720 HE Cartridges. The M983 is assembled with the M935 Point Detonating (PD) Fuze which is currently used on the 81mm M889 and 60mm M888 HE Cartridges.

2. CONCEPT OF TEST

The tests specified in this TDP, in addition to the other tests required by regulation, shall provide a basis for an independent evaluation of the M984/M983 HE Cartridges. Unless otherwise stated, the results shall be compared to the results of the Pre-Production Qualification Testing (PPQT) of the M984/M983 Cartridges, the development testing of the M821/M889 Cartridges and the Initial Production Testing (IPT) of the 81mm M879 Practice Cartridge. The requirements for the M984/M983 Cartridges are essentially the same as those of the M821/M889 rounds and are contained in the Required Operational Capabilities (ROC) document for the Improved 81mm (I-81) Mortar System.

3. SUBTESTS

3.1 General.

This section of the TDP defines specific subtests and related testing required to adequately address the test issues. The specified subtests are designed to address one or more of the test issues. Where possible, the tests are planned according to statistical designs to minimize test requirements. All firings shall be from a M252, 81mm Mortar. Wherever individual packaged cartridges are handled, they should be carried using the plastic handles on the individual package. Any incidents, problems or observations concerning the handles shall be reported.

3.2 Initial Inspection and Physical Measurements.

An initial inspection shall be conducted on each of the test rounds to determine if the rounds meet the requirements of the appropriate drawings. This inspection shall include weight measurements of the packaged and bare round - Special attention should be given to the presence of any HE residue on the test ammunition. X-raying of the test ammunition shall be conducted to inspect for HE filler voids.

3.3 U.S. Army Test and Evaluation Command (TECOM) Safety Tests.

Tests shall be conducted according to standard TECOM Test Operation Procedures (TOP), U.S. Army Regulations and Military Standards to determine if the subject ammunition is safe to store, transport, handle and fire in its expected modes and environments. The standard tests for safety testing of mortar ammunition are included in Table 1 below. TECOM will specify any additional testing that they may require to conduct safety evaluation of the subject ammunition. All M984 rounds shall be set for proximity (PRX) function and all M983 rounds shall remain set for superquick (SQ) function. Any incorrect projectile (fuze) function shall be reported. Special attention should be given to the M734 fuze functioning. Any reverse functions, back-up functions, early bursts prior to reaching maximum ordinate, early bursts after maximum ordinate or other incorrect functioning shall be reported.

Table 1. Safety and Adverse Environments Tests
(TECOM TOP TESTS)

TEST	APPROXIMATE SAMPLE SIZE	
	M984	M983
1. Hot-Dry Cycle	25	25
2. Cold Soak	25	25
3. Ammunition Cook-off	10	10
4. Charge Assessment/Pressure Verification	--	60 (I)
5. Strength of Design	--	15 (I)
6. Sequential Rough Handling	90	90
7. 12-Meter Drop Test	30	30
8. Secured Cargo Vibration	50	50
9. Rate of Fire	--	200 * (I)
10. Residue	--	400 * (I)
11. Blast Overpressure	--	70 (I)
12. Wet Efficiency	--	20
13. Immersion (unopened package)	--	10
14. Rain (reclosed package)	--	--

(I) - Inert
* - These quantities may be reduced by the U.S. Army Combat Systems Test Activity.

3.4 Performance and Reliability.

3.4.1 Ballistic Similitude. This test will provide the necessary ballistic data for verifying the Ballistic Research Laboratory (BRL) Firing Tables which were generated from results of the Firing Table testing of the M983 and M984 Cartridges during the PPQT (cartridges designated M889E1 and M821E1 at that time). BRL will make corrections to the Firing Tables, if necessary, after analyzing the results of this test. This test shall require 75, M984 and 75, M983 Cartridges for the actual test and 10 additional rounds of each for the contingency that good data are not obtained on any of the test rounds. The firing matrix for each cartridge type consists of all five propelling charge levels, three weapon elevations, and five rounds per cell. This corresponds to 15 combinations of Charges 0 through 4 and elevations of 1511, 1156, and 800 mils. When firing each cell, if complete data are not obtained on one or more of the five test rounds, contingency rounds shall be fired to complete the five round cell. Five good data test rounds are required by BRL to ensure computational accuracy and confidence. All rounds shall be fired conditioned to 70°F for at least 24 hours prior to firing. All M984 Cartridges shall be set for IMP (impact) fuze function. All M983 Cartridges shall be set for PD fuze function. The results of this test will also provide reliability data for both cartridges. Data requirements for this test are: range, deflection, muzzle velocity, time of flight, fuze and cartridge functioning attributes (dud, misfire, high order, early, delay, etc.), barrel pressure and meteorological data. The test shall be conducted while wind speed is below five meters per second. The mortar tube shall be swabbed after every 10 rounds (between cells, not within).

3.4.2 Temperature Extremes. Testing shall be conducted as described in this paragraph to obtain functioning reliability, range and Height of Burst (HOB) performance data in ambient and extreme operational temperatures. Special

attention should be given to the reliability problems encountered during the pre-production testing of the M983 and M984 Cartridges (at that time the M821E1 and M889E1 Cartridges). The M984 Cartridge demonstrated high M734 Fuze dud rates when fired at the combinations of cold temperature extremes, Charge 0, and high weapon elevations. This problem also occurred on the other 60mm and 81mm mortar cartridges fuzed with the M734 Fuze and the, PD only, M745 Fuze. The problem occurred only when the cold conditioned cartridges were fired in warm weather conditions which produced frost on the cartridges and within the fuze air inlets. The M734 developer, Harry Diamond Laboratories, believes that this resulted in a sufficient reduction in air flow to the air turbine to prevent the arming of the fuze under these low velocity firing conditions. The M983 Cartridge demonstrated high M935 Fuze dud rates due to continuing manufacturing and/or design problems with the M935. The testing shall be conducted in three phases described in the following paragraphs.

a. Phase 1 - M984 Ambient and Hot. This phase consists of firing M984 Cartridges set for PRX function using three charge/elevation combinations at both ambient (70°F) and hot (125°F.) temperatures. The firing matrix in Table 2 shall be followed. A weapon elevation of 1511 mils shall be used for the rounds fired at Charge 0. The rounds at Charge 4 shall be fired at 800 mils and the rounds at Charge 2 can be fired at any elevation between 1000 and 1300 mils. Given a selected elevation, all the Charge 2 rounds must be fired at that elevation to maintain the range and allow for the evaluation of range and precision.

Table 2. Temperature Extremes Test: Phase 1 - M984

	Sample Size		
	Charge		
Firing Temp. °F	0	2	4
70	10	10	10
125	10	10	10

All the test rounds shall be set for PRX function. Required measurements and data are: range and deflection of burst, HOB, muzzle velocity, coefficient of reflectivity of the impact area measured before and after each day's testing, cartridge and fuze functioning (dud, misfire, early, etc.), time of flight, estimates of range and HOB of any up or down-leg early fuze functions, meteorological data and any other pertinent observations.

b. Phase 2 - M984 Cold. This phase consists of firing M984 Cartridges set for PRX function, conditioned at temperatures ranging from extreme cold to ambient, into cold outside air conditions in order to greatly reduce the accumulation of frost on the test cartridges. The test shall be conducted according to the firing matrix in Table 3. The rounds at Charges 0 and 1 shall be fired at weapon elevation of 1511 mils. The rounds at Charge 4 shall be fired at a weapon elevation of 800 mils. The outside air conditions shall be preferably below 32°F and with low relative humidity. Efforts shall be taken to fire each test round as quickly as possible after removing the round from its container in

order to reduce any frost accumulation. If significant frost build-up is observed on the test rounds prior to firing, the test shall be suspended and resumed when conditions are such that the frost accumulation is at an acceptable level.

Table 3. Temperature Extremes Test: Phase 2 - M984 Cold

	Sample Size		
	Charge		
Firing Temp. °F	0	1	4
-50	10	10	10
-25	10	10	10

All fuzes shall be set for PRX function. Required measurements and data are the same as those required in Phase 1 in paragraph 3.4.2, subparagraph a. above.

c. Phase 3 - M983. This phase consists of testing the M983 Cartridge at both operational temperatures extremes and at ambient temperature at minimum, maximum, and intermediate charges. The test shall be conducted according to the firing matrix in Table 4. All fuzes shall remain set for PD function. A weapon elevation of 1511 mils shall be used for firing all the rounds at Charge 0. The rounds at Charge 4 shall be fired at an elevation of 800 mils. The rounds at Charge 2 shall be fired at any elevation between 1000 and 1300 mils. However, once an elevation is chosen, all Charge 2 rounds shall be fired at that elevation to maintain the range and allow for range and precision evaluation.

Table 4. Temperature Extremes Test: Phase 3 - M983

	Sample Size		
	Charge		
Firing Temp. °F	0	2	4
-50	10	10	10
-25	10	10	10
70	10	10	10
125	10	10	10

Required measurements and data are range and deflection, muzzle velocity, time of flight, cartridge and fuze functioning (dud, misfire, short round, etc.), meteorological data and any other pertinent observations.

3.4.3 Fragmentation Testing. Fragmentation testing is required to verify that the fragmentation characteristics of the M984/M983 production projectiles have not changed from those evidenced by the prototype projectiles tested during the PPQT testing. At a minimum, a pit fragmentation test shall be conducted with one test projectile. The fragments collected from this test shall

be categorized by size and weight. This data shall then be provided to AMSAA. AMSAA will compare this data to the PPQT data and then make a determination whether further fragmentation testing is necessary. If further testing is considered necessary, additional pit testing may be requested or an arena fragmentation test may be requested. Given that no design changes have been made to the cartridge body, explosive fill, or booster charge, no significant differences in fragmentation characteristics are expected. If no significant difference in the fragment size and weight distribution is found, it will be assumed that the velocity and spatial distribution characteristics estimates calculated from the PPQT test results are also not significantly different.

3.5 Air Deliverability.

The M984/M983 Cartridges are expected to withstand the severe treatment associated with being air dropped or delivered without causing unexpected safety hazards or degrading their functioning performance and reliability. This capability shall be evaluated on the basis of tests using the standard procedures for air-dropping and delivering mortar ammunition. These tests shall include all standard delivery methods from fixed and rotary wing aircraft. Following the delivery or drop tests, ballistic tests shall be conducted on all rounds considered safe to fire. In addition, a control sample of 10 rounds not air-dropped shall be fired on the same test occasion. The formal test procedures, sample size and other details are the responsibility of Natick Laboratories and the actual test agency. However, given the pallet and overpack configuration of these cartridges, a sample of 70 of each cartridge should be sufficient in addition to the 10-round control sample of each cartridge type. All rounds to be fired shall be fired at Charge 4 and 800 mils elevation. The M984 Cartridges shall be set for PRX fuze function and the M983 Cartridges set for PD function. All rounds fired shall be temperature conditioned to 70° F for at least 24 hours prior to firing. Data requirements for the M984 ballistic tests are; delivery method, range and deflection of burst, HOB, muzzle velocity, cartridge and fuze functioning (dud, misfire, early, etc.), time of flight, estimates of range and HOB of any up or down-leg early fuze functions, meteorological data and any other pertinent observations. Data requirements for the M983 ballistic tests are: delivery method, range and deflection, muzzle velocity, time of flight, cartridge and fuze functioning (dud, misfire, short round, etc.), meteorological data and any other pertinent observations.

4. RELIABILITY

4.1 General.

The ROC for the I-81 Mortar System does not contain reliability requirements for the M984/M983 Cartridges or the M821/M889 Cartridges. Therefore, reliability goals for the M984/M983 shall be established by considering requirements for similar mortar cartridges and the reliability results of the PPQT testing of the M984 and M983 Cartridges. The M984/M983 reliabilities shall be estimated from the results of all applicable tests in this TDP including safety tests where over-abuse conditions were not used. Table 5 lists the tests in this TDP that shall be considered for reliability estimation. Estimates of misfire rate shall be calculated from the results of all applicable tests including those in which inert rounds were fired and from the IPT test

results of the M879 Practice Cartridge, which shares the same propelling system. During the testing, all failures and irregularities of the test ammunition and weapon(s) shall be reported regardless of severity. This data should include complete descriptions of the failure and the corrective action taken and the amount of down time and maintenance time used. The table in the Appendix lists the subtests specified in this TDP and the evaluation issues that the tests address.

4.2 M984 Reliability Goal.

During PPQT testing, the only reliability failures of the M821E1 and M889E1 were fuze failures. No misfires or short range rounds occurred. The M821E1 demonstrated an overall functioning reliability of 0.962 with an 80 percent lower confidence bound of 0.952. During surveillance testing in 1991 of the 60mm M720 and 81mm M821 HE Cartridges, which are both fuzed with the M734 Fuze, both demonstrated reliabilities over 0.96 as a point estimate. Considering these facts, it is reasonable to expect the M984 Cartridge to demonstrate a reliability at least as good as the PPQT demonstrated reliability. Given the quantity of 435 M984 Cartridges shown in Table 5, which will be considered for estimating reliability, up to 16 failures are allowed in order to demonstrate the PPQT M821E1 Cartridge reliability of 0.951 with 80 percent confidence.

4.3 M983 Reliability Goal.

The M889E1 Cartridge demonstrated unacceptable reliability during PPQT testing entirely due to defective M935 Fuzes. Manufacturing problems with the M935 Fuze caused increased dud rates over time, which were not noted during the fuze lot acceptance testing. Because of these fuzes, the M889E1 demonstrated a temperature dependent fuze reliability. At cold temperature extremes (-46°C) a dud rate of 21.4 percent occurred. At ambient conditions, a dud rate of 7.8 percent occurred and at the high temperature extreme (63°C) a rate of 5.0 percent was demonstrated. Other mortar cartridges with PD Fuzes have typically demonstrated high reliability. Surveillance testing of the 60mm M49A4 HE, M302A1 Smoke; 4.2 Inch M329A2 HE and M328A1 Smoke cartridges have, except for some degraded stockpile portions, demonstrated reliabilities of at least 0.98. The recent IPT testing of the 60mm M722 Smoke Cartridge, which is fuzed with the M745 PD Fuze, demonstrated a reliability of over 0.99. Considering these facts, it is reasonable to expect the M983 Cartridge to demonstrate a reliability of 0.98 with 80 percent confidence. The number of M983 Cartridges to be used for estimating reliability, as shown in Table 5, is 465. With this sample, up to six failures are allowed in order to demonstrate a 0.98 reliability with 80 percent confidence.

Table 5. Subtests to be used for Reliability

TEST	SAMPLE SIZE	
	M984	M983
1. Hot Dry Cycle	25	25
2. Cold Soak Cycle	25	25
3. Sequential Rough Handling (excluding bare drop)	60	60
4. Secured Cargo Vibration	50	50
5. Wet Efficiency	--	20
6. Immersion (unopened package)	--	10
7. Firing Tables	75	75
8. Performance and Reliability	120	120
9. Air Delivery	80	80
TOTALS	435	465

5. ORDER OF TESTING

The testing should be conducted in an order that will make the most efficient use of personnel and facilities and aid in the evaluation of results. The TECOM safety tests should be conducted first so that the safety evaluation may be completed by TECOM early in the testing. The Firing Tables test should also be conducted early because of the time needed to develop the Firing Tables from the data. The Pit Fragmentation test should be conducted early-on in order for the results to be analyzed by AMSAA so that the determination can be made whether further fragmentation testing is required.

6. ACCURACY OF MEASUREMENT

Observations and measurements shall be made with the degree of accuracy given below.

6.1 Physical Measurements.

a. Weight of projectile, unit packaging, etc. (± 1 gm)

b. Surface dimensions (± 0.5 mm)

c. Conditioning Temperature (± 1°F)

d. Tube Elevation (± 1 mil)

6.2 Interior Ballistics.

Muzzle Velocity (± 0.1 meters/sec)

6.3 Exterior Ballistics.

a. Range and Deflection	(± 5 meters)
b. Time of Flight	(± 1 second)
c. Height of Burst	(± 1 foot)

6.4 Meteorology.

a. Barometric Pressure	(± 1 mbar)
b. Wind Direction	(± 10°)
c. Wind Velocity	(± 1 meters/sec)
d. Temperature	(± 1°F)
e. Relative Humidity	(± 1 percent)

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APPENDIX

SAMPLE SIZES VERSUS EVALUATION ISSUES

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SAMPLE SIZES VERSUS EVALUATION ISSUES

TEST	SAMPLE SIZE M984 / M983	EVALUATION PROCESS			
		RELIABILITY	SAFETY	PERFORMANCE	SUPPORT
Safety Tests (c)	230 / 975 (a)	X (b)	X	X	
Adverse Environments	0 / 30	X	X	X	
Firing Tables	75 / 75	X	X	X	
Pit Fragmentation	0 / 1			X	
Performance & Reliability	120 / 120	X	X	X	
Air Delivery	80 / 80	X	X	X	X

(a) - 745 Inert

(b) - 160 of each cartridge from the safety shall be considered for estimating reliabilty.

(c) - Standard TECOM TOP Safety Tests.

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